Non-Invasive Characterization Of Small-Scale Patterns Of Benthic Biogenic Structure By Ultrasound: Infaunal Dynamics And Sediment Structure, And Effect Of Sediment Disturbance

Donald G. Webb
Graduate School of Oceanography
University of Rhode Island
Narragansett, RI 02882
Voice:(401) 874-6608; Fax: (401) 874-6613; email: dwebb@gsosun1.gso.uri.edu

Candace A. Oviatt
Graduate School of Oceanography
University of Rhode Island
Narragansett, RI 02882
Voice:(401) 874-6132; Fax: (401) 874-6613; email: coviatt@gsosun1.gso.uri.edu

Award # N00014-96-1-0374
http://www.onr.navy.mil/sci_tech/ocean/onrpgahj.htm

LONG TERM GOALS

Our goal is to examine how temporal changes in marine, soft-sediment infaunal density, distribution and species composition affects sediment surface roughness and below-surface structure. The use of commercial ultrasonic sensors allows us to examine temporal patterns in biogenic structure and roughness on fine spatial scales (mm) without invasive disturbance. In addition, we are examining how physical disturbance of the sediment affects biogenic structure, both above and below the sediment surface, and determining whether disturbed sediments exhibit a "signature" in terms of patterns of biogenic structure.

OBJECTIVES

Our major objectives are twofold: 1) How does biogenic structure at and below the sediment surface change in sediment assemblages under controlled conditions? What is the temporal persistence of relict biogenic structure under undisturbed conditions?; and 2) How does biogenic structure respond to different frequencies of physical sediment disturbance under controlled conditions? Does physical sediment disturbance leave a "signature" in terms of biogenic structure?

APPROACH

We possess 16 flow-through chambers (120 X 14 X 27 cm) which allow maintenance of benthic assemblages from both nearshore and continental shelf habitats for extended periods under controlled conditions. The 16 chambers are connected to a head tank that continuously receives seawater pumped from Narragansett Bay, RI. The water in the head tank is temperature-controlled to not exceed 15^{o}C.

The general experimental approach is to collect sediment in the field, transport it back to the laboratory, add it to the experimental chambers, and then manipulate and image the sediment structure as required.

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **1998**	2. REPORT TYPE	3. DATES COVERED **00-00-1998 to 00-00-1998**
4. TITLE AND SUBTITLE **Non-Invasive Characterization Of Small-Scale Patterns Of Benthic Biogenic Structure By Ultrasound: Infaunal Dynamics And Sediment Structure, And Effect Of Sediment Disturbance**		5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)		5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **University of Rhode Island,Graduate School of Oceanography,Narragansett,RI,02882**		8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S) 11. SPONSOR/MONITOR'S REPORT NUMBER(S)
12. DISTRIBUTION/AVAILABILITY STATEMENT **Approved for public release; distribution unlimited**		
13. SUPPLEMENTARY NOTES **See also ADM002252.**		
14. ABSTRACT		
15. SUBJECT TERMS		

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**4**	

Imaging is conducted with an ALOKA SSD 500 ultrasound machine (purchased with a previous ONR grant to Carey et al. at URI) or with a Toshiba Eccocee 300 color Doppler unit (purchased from this grant). The acquisition of the color Doppler unit expands our capabilities greatly by allowing real-time measurement of flow concurrently with the sediment imaging. We have used 7.5 MHz probes for our current imaging because of the high resolution coupled with adequate sediment penetration (4 cm). The probes are mounted parallel to the sediment surface and moved in known 3-D space using a macro-positioning system constructed from optical rails. We can then relate the ultrasound images to 3-D space in the flow chambers. The ultrasound images are captured on videotape and then ported to a PC with a PCI-bus video capture card for subsequent software-based enhancement and image processing. With appropriate macro scripts written in Matlab, we can then produce a 3-dimensional map (areal and with depth in the sediment) of biogenic structure in our chambers.

WORK COMPLETED

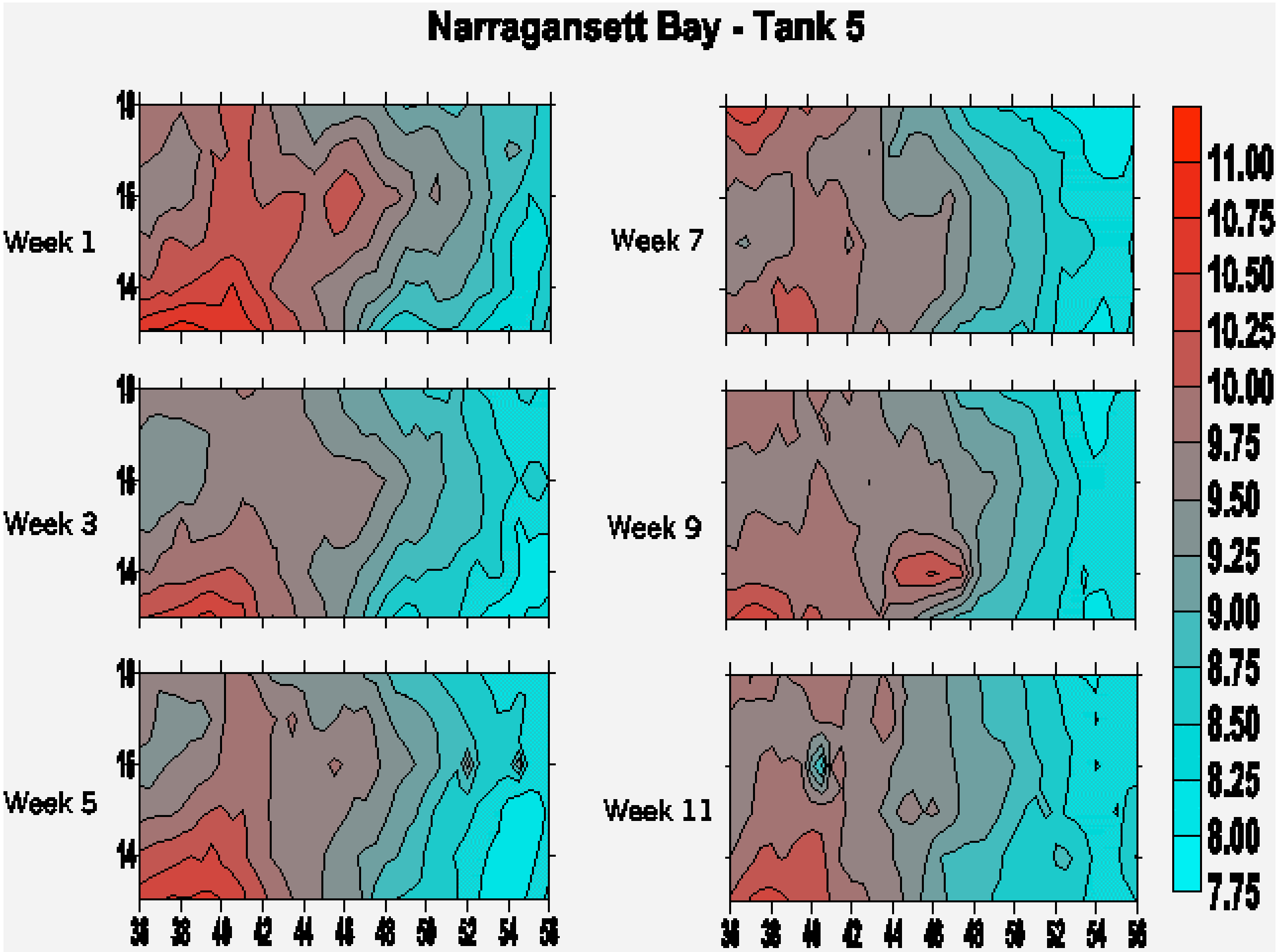
All ultrasound images from the 3 month duration experiments designed to examine Objective # 1 (FY 1996) and Objective # 2 (FY 1997) have been analyzed and description of surface features and volume of subsurface inhomogeneities has been completed.

RESULTS

Sediment surface roughness patterns changed as a function of the development of specific faunal patch structures throughout the experimental duration (3 months) and different frequencies of disturbance altered the sediment structure determined acoustically. Surface roughness features could be mapped with 1mm horizontal and vertical resolution and subsurface structure (tubes, voids and other volume inhomogeneities) could be mapped with similar resolution to 3 – 4 cm below the sediment surface.

Patterns in biogenic structure (e.g. tubes) from the initial (FY 1996) experiment appear to be stationary on the order of 2 weeks. However, even in the absence of physical disturbance, sharp discontinuities in spatial pattern occur at this time scale rather than the appearance of gradual changes. These sharp changes appear to be related to the production of new biogenic structure (tubes). These sharp changes can be observed in the accompanying figure

This figure shows the changes in sediment height (vertical color scale) of a 5 X 20 cm (vertical and horizontal axes) section of sediment from Narragansett Bay over an 11 week period. The rapid creation and disappearance of tubes and pits is evident, especially from weeks 7 to 11.



Patch structure is sharply dynamic and is often not a function of the gradual blending together of existing spatial structure. This is supported by our results showing that some structural features change more at hourly intervals than at weekly intervals (a temporal smoothing). These results have serious implications for the temporal scale of analysis of infaunal spatial patterns and effects of bioturbation on benthic processes.

Sediment disturbance, as expected, led to dramatic changes in both surface roughness and the abundance of subsurface volume inhomogeneities. Different frequencies of sediment disturbance (weekly vs. monthly) led to differential abilities of the infaunal assemblage to recover, with more frequent disturbance being more detrimental to structural recovery.

IMPACT

This research has provided new information on temporal changes in small-scale patterns of benthic biogenic structure and infaunal patch dynamics. Also, we have examined the structural signal of disturbed sediments and infaunal responses to disturbance in a way never performed before. Studies on temporal patterns in biogenic structure and patch dynamics have been severely hampered by the inability to sample without disturbing the sediment. The use of ultrasound technology allows us to make a major breakthrough in the analysis of sediment systems.

TRANSITIONS

Both Year 1 and 2 tasks and goals have been achieved. Given the success of this research, a further year of funding has recently been approved by the ONR Biological and Chemical Oceanography program to create a field-deployable ultrasound machine. The goal of the new research is to examine sediment structure before and after sediment resuspension events caused by atmospheric storms.

RELATIONSHIP TO OTHER PROJECTS

The Doppler system has been used heavily by students of T. Hara's, who are evaluating its potential in the analysis of dense, fluidized sediment flows. In addition, we have had enquiries from European scientists on the feasibility of using ultrasound in some benthic experiments (bioturbation rates) planned for the near future.